

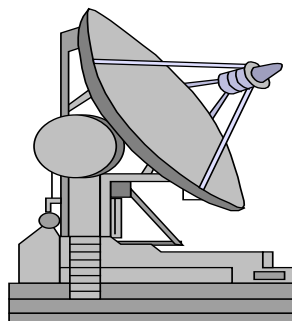
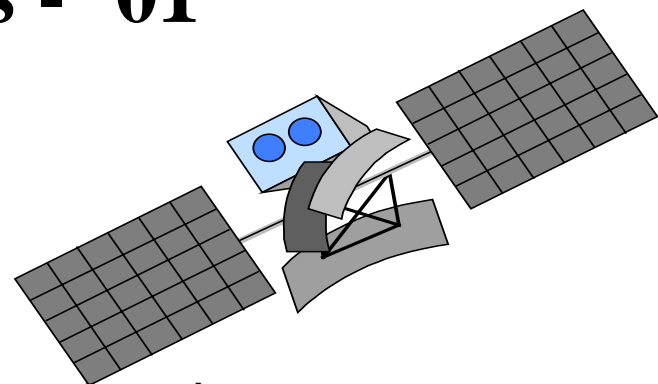


Wireless Telemetry for Industrial Applications

Sensors and Controls - '01

DOE/OIT

June 7, 2001



Wayne W. Manges (mangesww@ornl.gov)

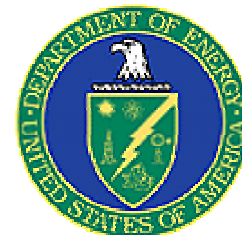
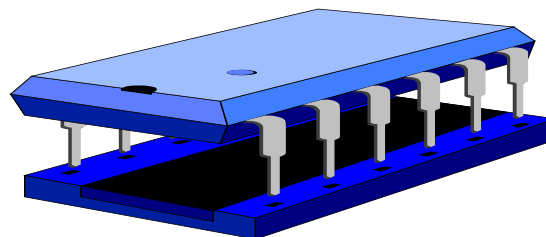
Timothy J. McIntyre

Stephen F. Smith

Glenn O. Allgood

Michael R. Moore

Roberto Lenarduzzi



[Http://orcmt.oakridge.org/wireless](http://orcmt.oakridge.org/wireless)

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UT-BATTELLE

Our Third Year Demo Showed Feasibility



- Standards - IEEE 1451, Ethernet, 4-20ma
- Communication - Direct Sequence, Spread Spectrum, CDMA RF
- Robust - 140 feet in Bowater paper mill

We Accomplished What We Set Out To Do

- **Year 1 - Functional Description and Requirements - some surprises, several external requests**
- **Year 2 - Architecture Specification, components - more external requests**
- **Year 3 - Integrated systems and Demo - external requests and potential partners**

Challenges in Wireless Technology Identified by National Research Council

- **Eliminating Interference - reliable communications**
- **Developing Intelligent Wireless Sensors - reduced deployment cost**
- **Developing Robust Architectures - for harsh environments**
- **Developing Remote Power - long lasting and reliable**
- **Developing Standardized Protocols - plug-and-play (without the plug)**

Key Requirements Identified

- **Operate Unattended - Reduced cost of deployment and maintenance**
 - self-configuring,
 - self starting,
 - self healing
- **Support Legacy Systems - Sensors and networks, open standards (1451)**
- **Operate in Industrial Environment - temperature, dust, vibration**

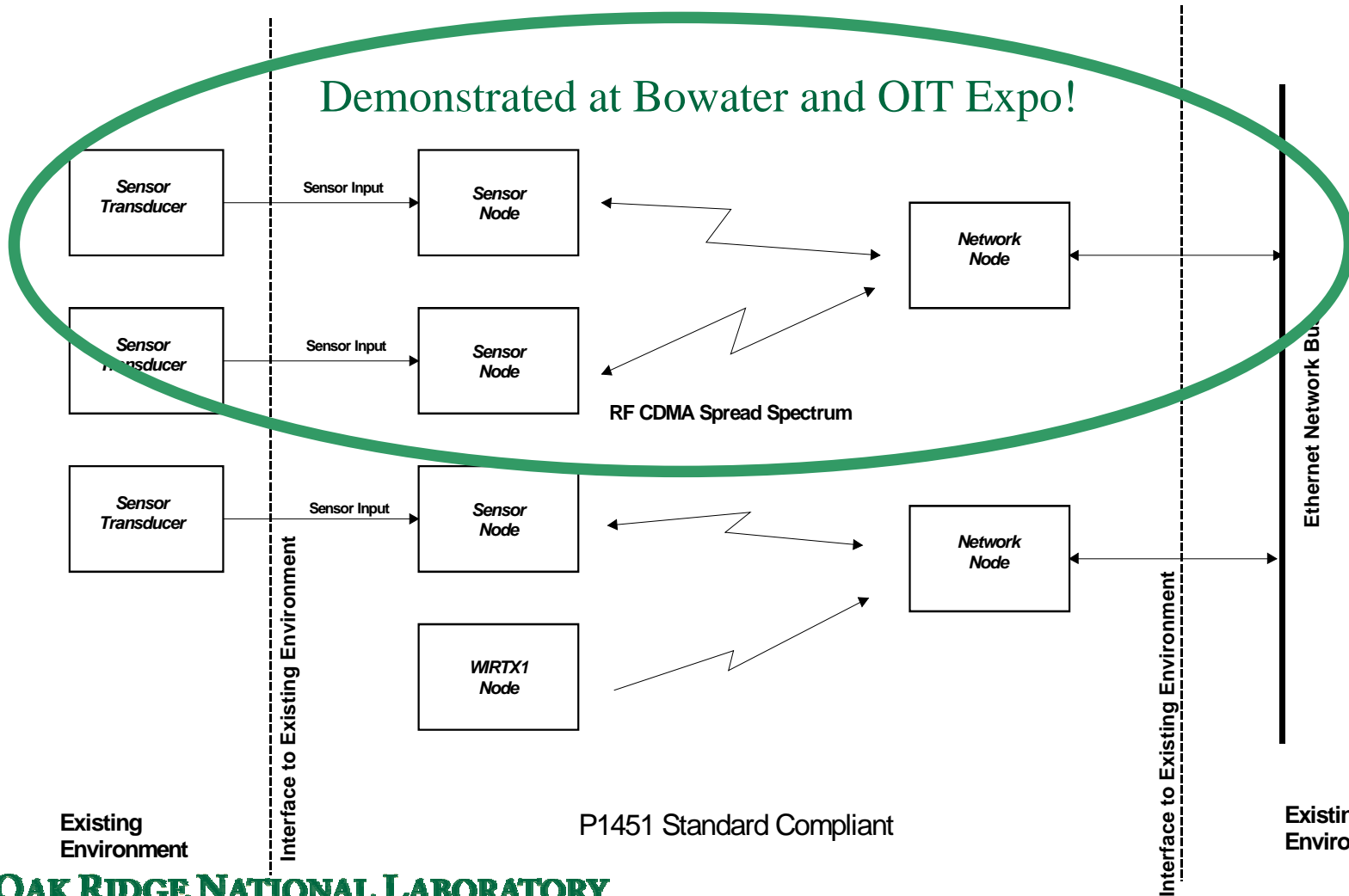
Features Documented in Architecture Spec

- **Architecture - DSSS, CDMA, peer-to-peer, hierarchical, dynamic**
- **Testbed - IEEE 1451 (Smart Sensor) compliant, Performance metrics established**
- **Path Forward - smaller footprint, higher performance, third-party support**

DOE/OIT Board Level Wireless Test Bed

Overall System Block Diagram

Demonstrated at Bowater and OIT Expo!



Existing
Environment

P1451 Standard Compliant

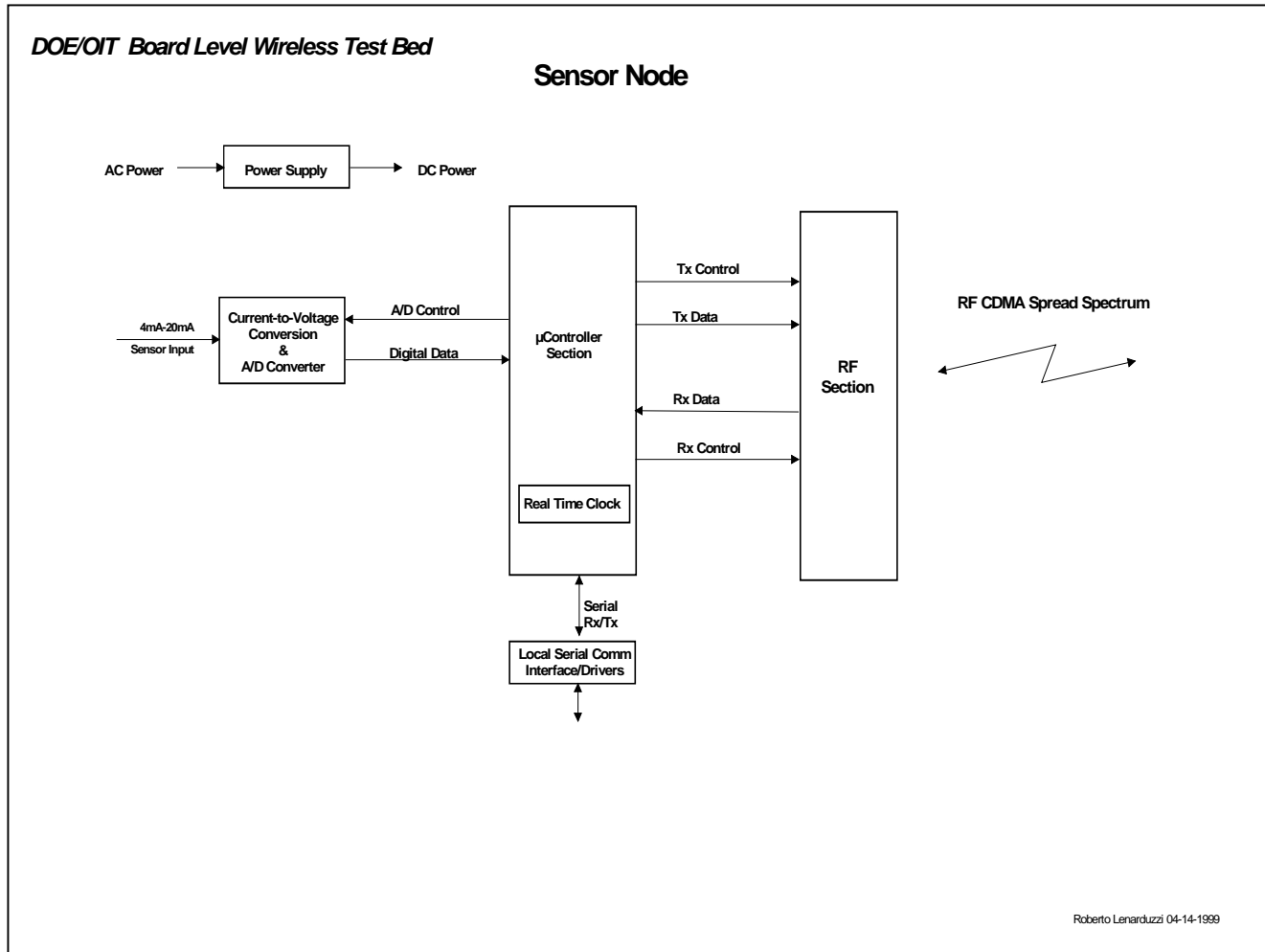
Existing
Environment

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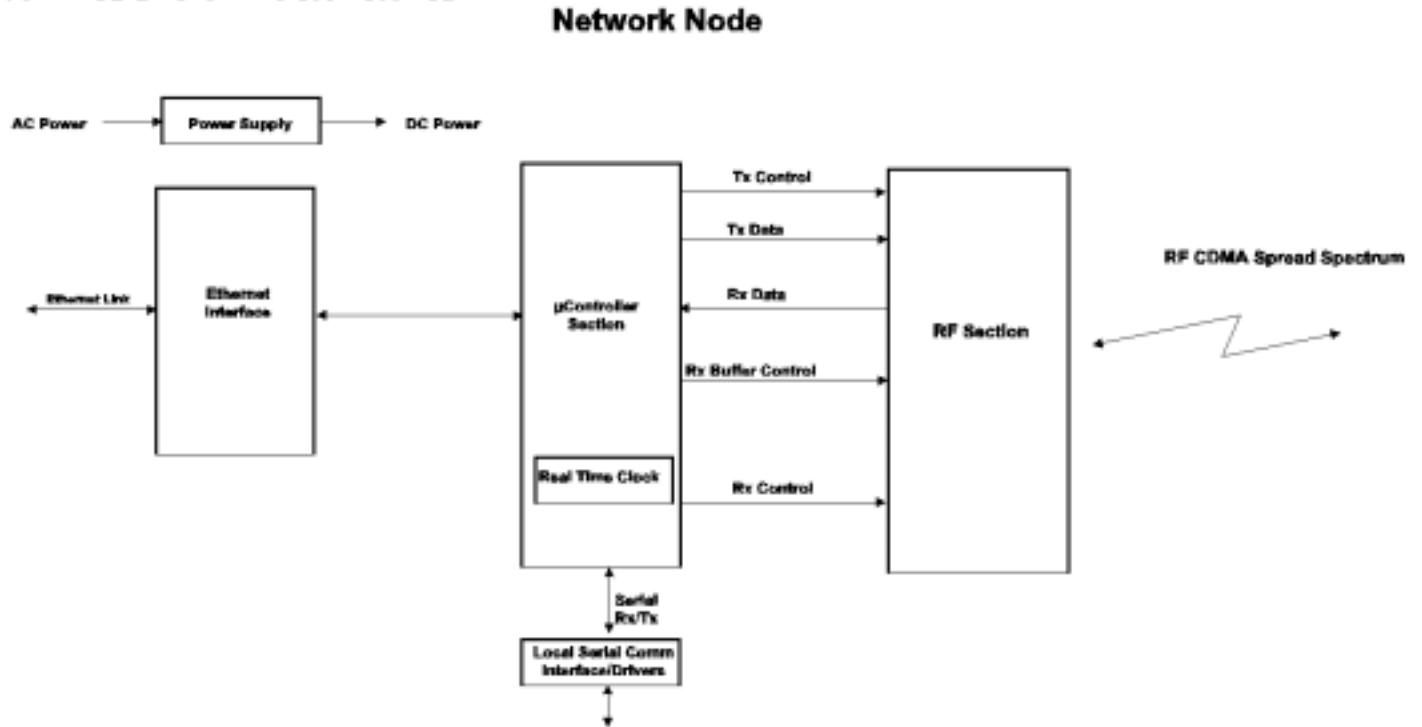
Roberto Lenarduzzi 04-14-1999

Architecture Designed For Miniaturization

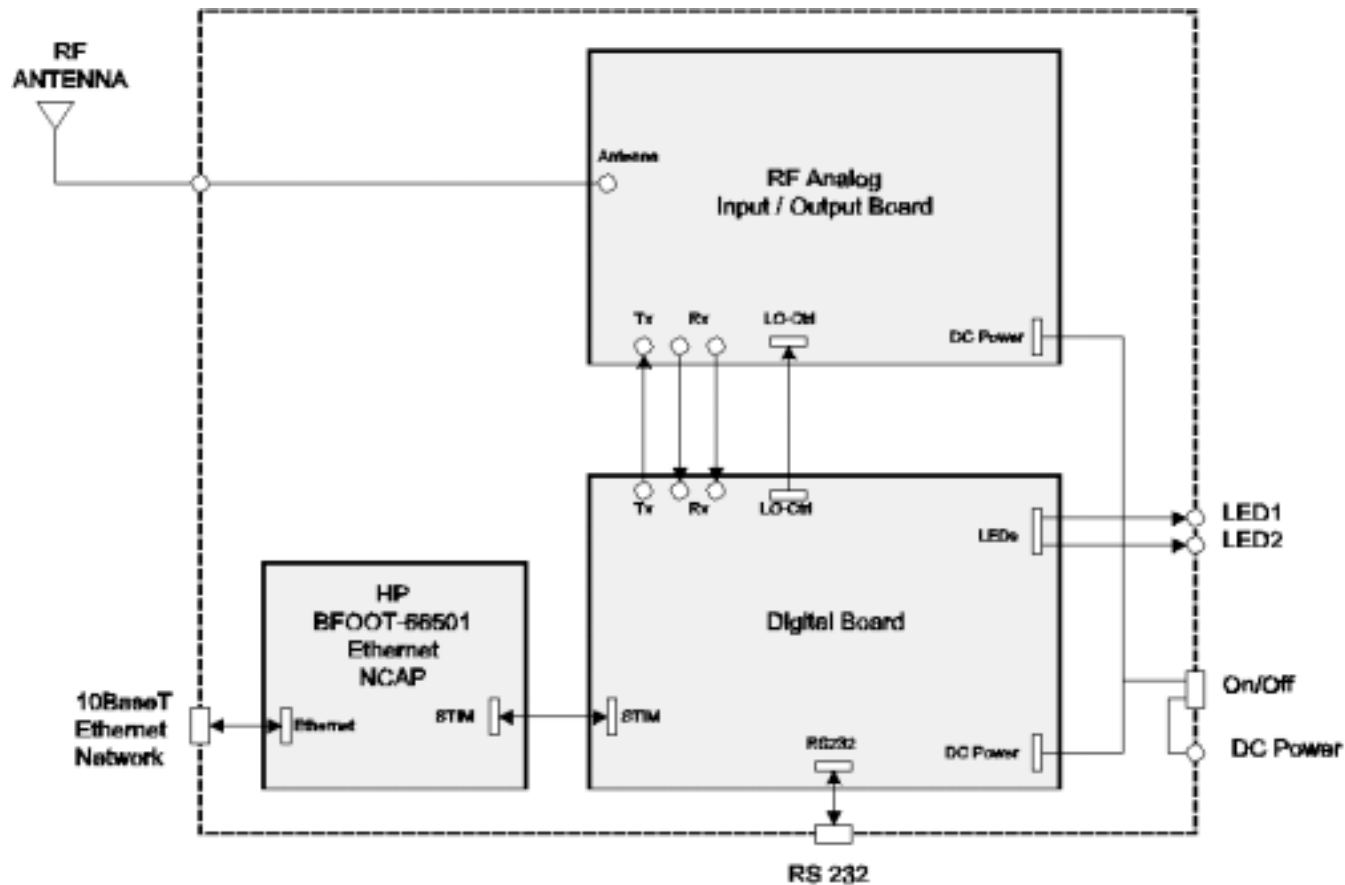


Measurement Provided to Existing Industrial Network

DOE/OIT Board Level Wireless Test Bed



Modular Design For Reuse

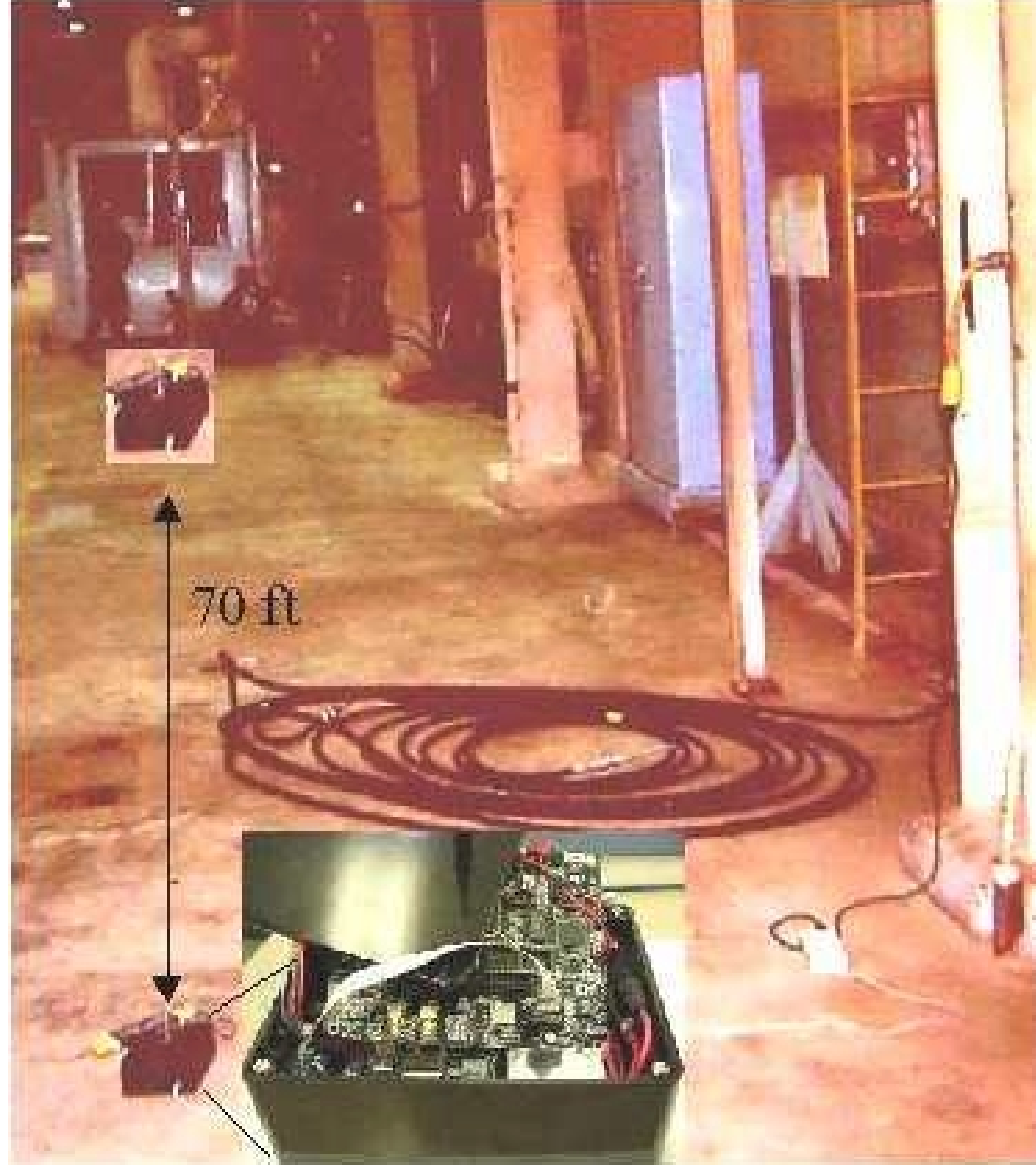


Network Node Box

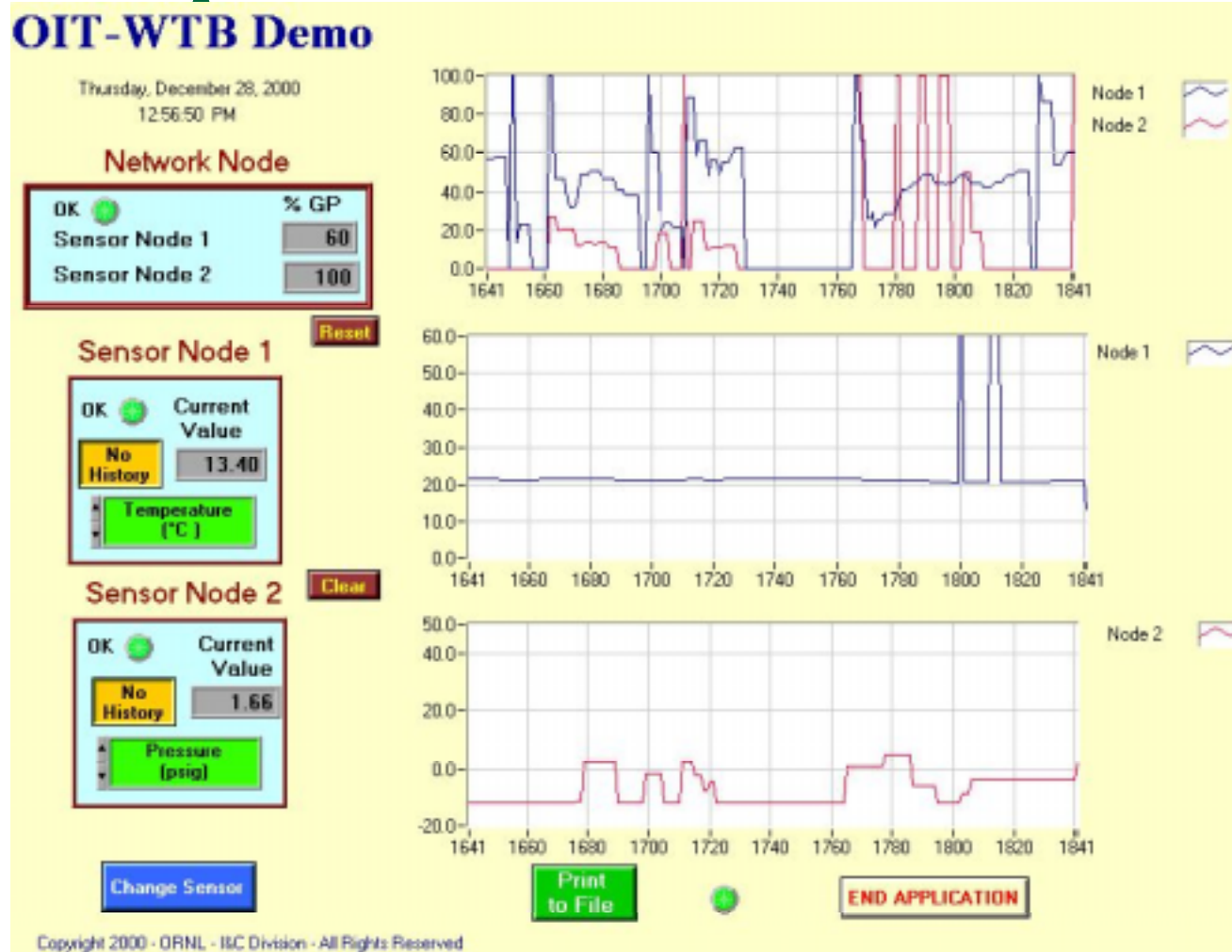
Demonstration in Bowater Plant Proved Performance

- **Robust - up to 140 feet in harsh environment**
- **Standards - 4-20ma standard pressure and temperature sensors, IEEE 1451 data structures, ethernet**
- **Throughput - updates suitable for real-time displays**
- **Low Power - 1/10000 power density of narrow band systems**

- **Standards - IEEE 1451, Ethernet, 4-20ma**
- **Communication - Direct Sequence, Spread Spectrum, CDMA RF**
- **Robust - 140 feet in Bowater paper mill**



Connection Doesn't Require 100% Success



SiGe Work Begun on This Project

- **AMS SiGe process has f_T up to 30 GHz, adequate for 5.8 GHz systems**
- **Two SiGe chips have been designed and submitted for fabrication**
 - **Individual devices for characterization and model verification**
 - **Several RF functional blocks needed for a 5.8 GHz bi-directional system**

Wireless Program at ORNL

Provided Significant Leverage

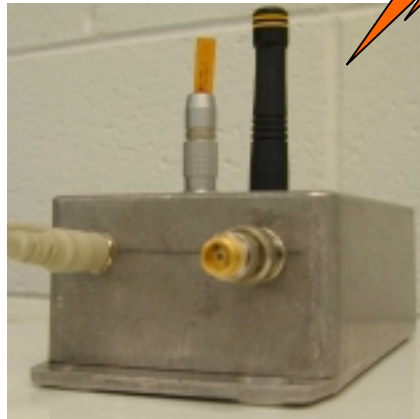
- **LDRDs - wireless microsensors, embedded wireless biosensor - \$1.5M**
- **Commercial Supplier - wireless MEMS - \$4M**
- **Oil Industry - robust architecture - \$1.5M**
- **Navy - Power management for wireless sensors - \$555K**
- **NASA - launch vehicle status - \$1M**

Follow-on Projects Benefit

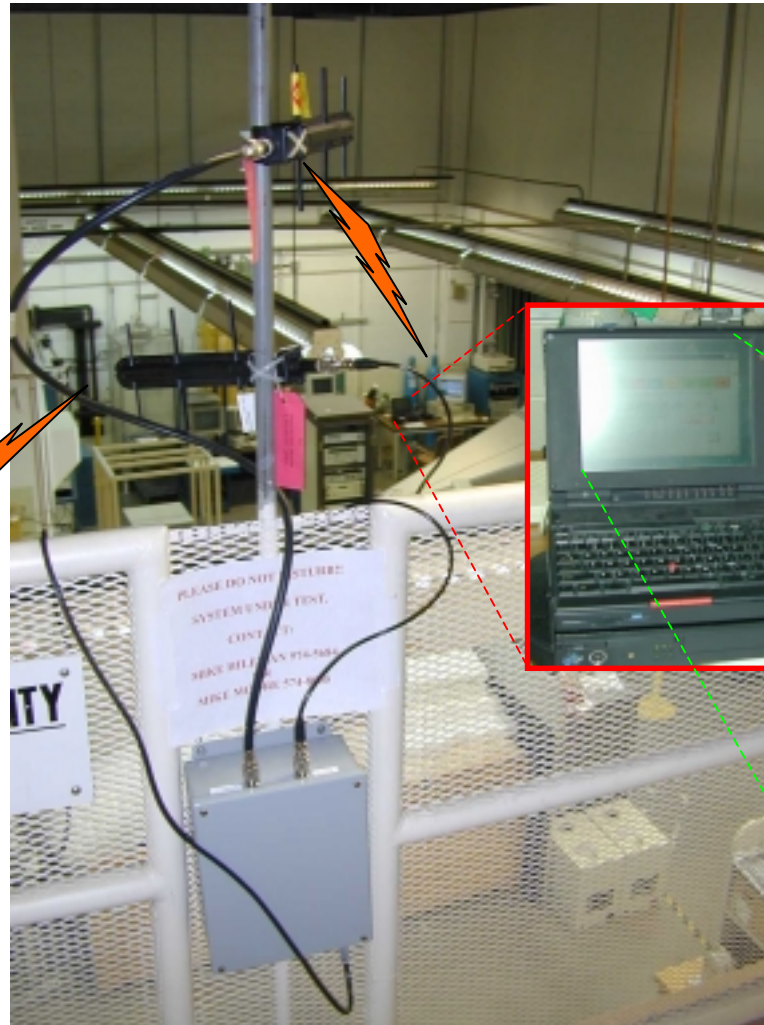
- **Steel - Timken -
wireless
temperature of steel**
- **Pulp and Paper -
wireless moisture
sensor**
- **Defense Logistics
Agency - wireless
tags**



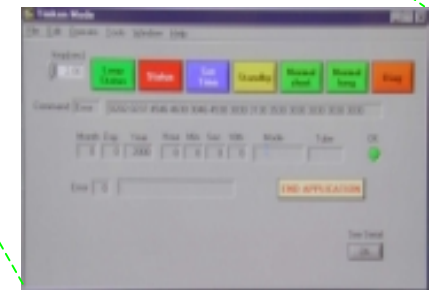
Spread-Spectrum IEEE 1451.3 Protocol Demo



Closeup of Transceiver



Data Screen



Control Screen

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ORNL RF Test Site

UT-BATTELLE

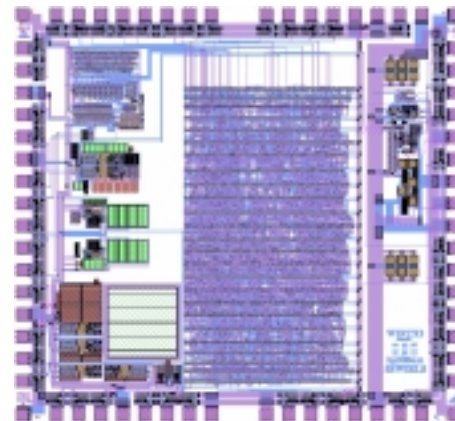
Our Path is Clear



← 10 cm (4 inches) →

Ground breaking work in:

- Wireless protocols
- Mixed Signal ASICS
- Low Power Designs



← 3.3 mm (1/8 inch) →

Impact of Market Penetration Expected to Be Significant

- **\$15B per year business - wireless sensors and industrial communication**
- **\$200 - \$2000 per foot - wiring costs in industrial facilities**
- **Mobility and Agility - moving components can stay connected**
- **Safety/Compliance - personnel and emissions**

Critical Next Steps Awaiting Funding and Partnerships

- Self-Powered - harvesting, helium ion-based batteries
- Smaller Footprint, Improved Noise Immunity - SiGe ASICs
- Reliability - error detection/correction
- Embedded Intelligence - Sensor Agents

Ready For Best Practices Call - Sign Up Now!

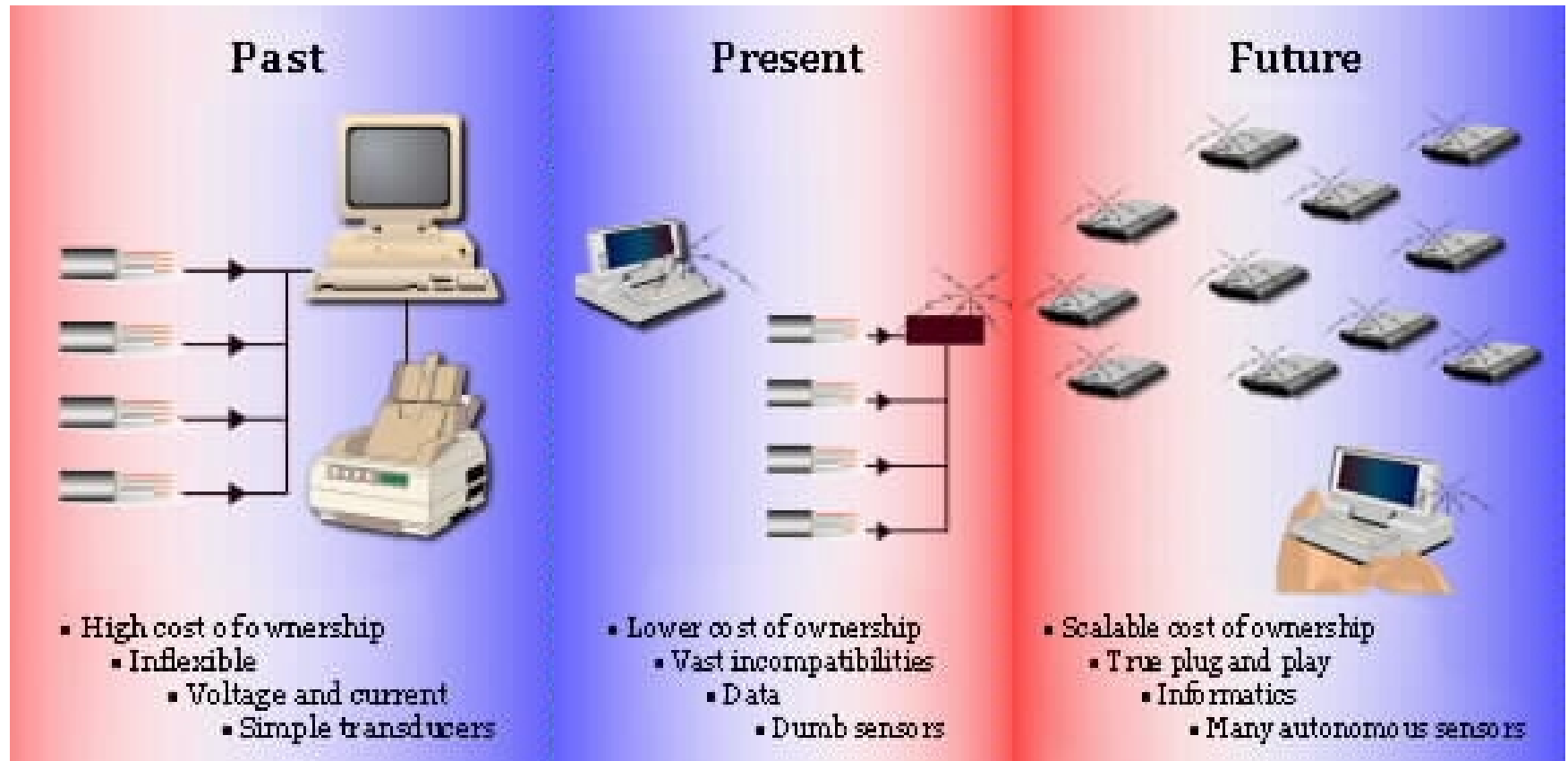
Our Project Highlighted in April 2000 Issue of Sensors Magazine



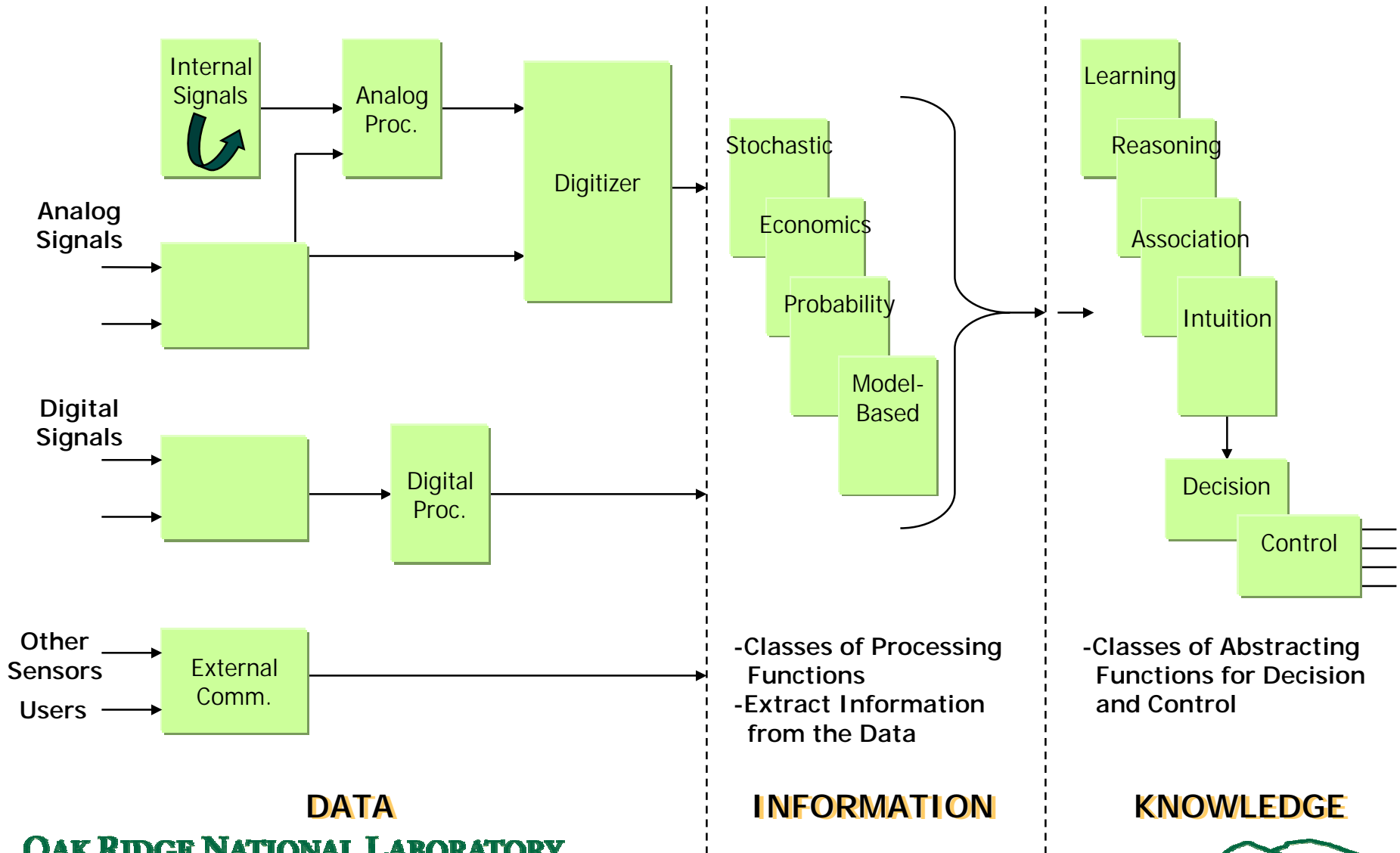
Follow-up Article in April 2001 Stressed Wireless Sensor Issues



The Future: The Sensor IS the Network



Embedding Classes of Functions for Information Abstraction



DATA

INFORMATION

KNOWLEDGE

Project Successful - Work Continues as Funding Allows

- **Demo - 140 feet but why not more?**
- **Power - wall power harder to get than expected - need power scavenging**
- **Size - need smaller size and internal antenna**
- **Partners - some in place, need more**